Airborne Electromagnetic Sounding of the Interiors of Venus, Mars, and Titan

Completed Technology Project (2016 - 2018)

Project Introduction

1. Science Goals Electromagnetic (EM) sounding uses induction from natural sources to build profiles of electrical conductivity of planetary interiors. The techniques of EM sounding performed previously for the Moon and Galilean satellites operate globally at very low frequencies (<<1 Hz) and cannot resolve structures of interest in crusts and upper lithospheres, which are comparatively shallow. We have developed a new theory for EM sounding that targets higher frequencies that can resolve this depth interval and applies anywhere in the waveguide formed between the ground and the ionosphere (Grimm et al., Icarus, 2012). An aerial platform at any altitude can perform the measurements over a long traverse, and so the approach is applicable to Venus, Mars, and Titan, which have complementary waveguide structures and potentially appropriate EM sources. Driving science questions include the lithospheric structure of Venus and its relation to that planet's unique geodynamic style, groundwater on Mars, and a subsurface ocean on Titan. Horizontal resolution is comparable to altitude (tens of km) but this is more than adequate to assess large-scale variations in crustal and lithospheric properties described above. Here, we propose to develop a prototype high-altitude airborne electromagnetic sounding system and test it on a stratospheric balloon. 2. Methodology The system will comprise three-component electrometers and searchcoil magnetometers, a GPS-aided inertial navigation system, ADC/computer, batteries, and thermal and impact management. The system will be tested in the lab, on the ground in the field, on a static balloon, and finally on a stratospheric balloon. The balloon provider will supply the balloon, gondola, and recovery system under a separate NASA contract. Two flights will assess the vertical variation of AC electric fields in the waveguide, the ability to recover vertical and lateral profiles of ground resistivity, and the time-variable effect of the ionosphere. Independent surface measurements will provide ground truth. The project will demonstrate the theory and practice of high-altitude EM sounding for planetary exploration as well as lessons learned to develop higher TRL hardware. 3. Relevance This instrument addresses the PICASSO call for development of spacecraft-based instrument systems to the point where they could be proposed to the MatISSE high-TRL program. Our TRL 2 entry is based on publication of the theory. The development would move through experimental proof-of-concept (TRL 3) by measuring and interpreting the relevant EM fields at high altitude. The exit TRL 4+ is based on the validation of all components in the lab and on the balloon, but it is not TRL 5-6 because we are not approaching the environmental conditions of the target objects, nor are we attempting to define the form, fit, and function of a flight instrument. The proposed instrument is relevant to Discovery, Mars Exploration program, and flagship missions that have called for balloon exploration of Venus, Mars, and Titan.

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Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Responsible Program:

Planetary Instrument Concepts for the Advancement of Solar System Observations

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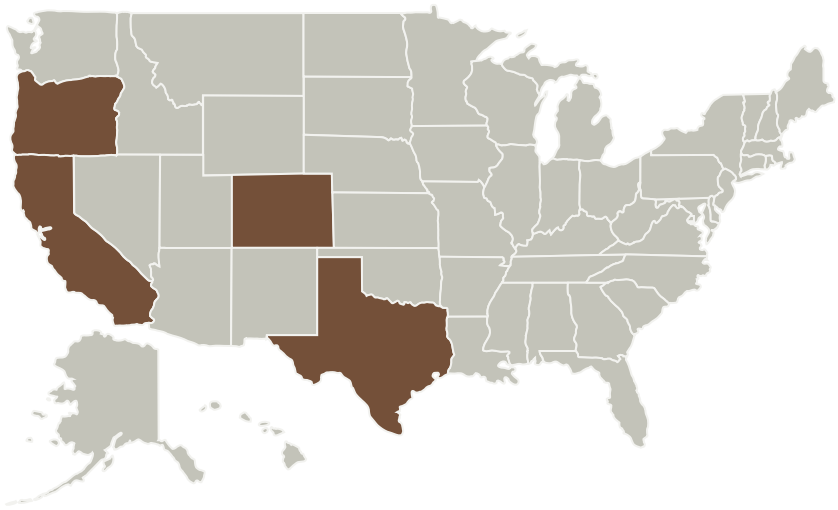
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Southwest Research Institute - San Antonio(SWRI)	Supporting Organization	Academia	San Antonio, Texas

Primary U.S. Work Locations	
California	Colorado
Oregon	Texas

Project Management

Program Director:

Carolyn R Mercer

Program Manager:

Haris Riris

Principal Investigator:

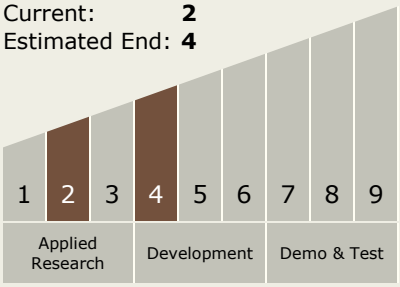
Robert E Grimm

Co-Investigators:

David E Stillman
Charles P Oden
Ronald B Kalmbach
Russ Dewey
Yongming Zhang

Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **4**



Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.3 In-Situ Instruments and Sensors
    - TX08.3.1 Field and Particle Detectors

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Target Destination

Others Inside the Solar System